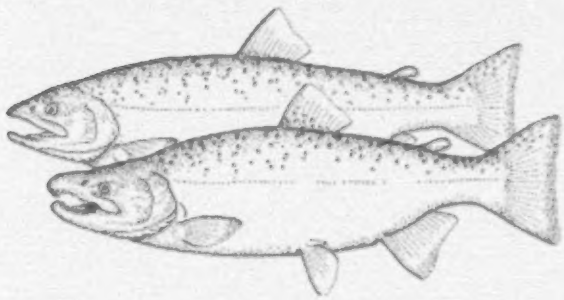
Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Pacific Region

Canadian Science Advisory Secretariat
Science Advisory Report 2015/008

ESTIMATES OF A BIOLOGICALLY-BASED SPAWNING GOAL AND BIOLOGICAL BENCHMARKS FOR THE CANADIAN-ORIGIN TAKU RIVER COHO STOCK AGGREGATE



Coho Salmon — provided by Fisheries and Oceans Canada, Freshwater Fishes of Canada, 1973 Fisheries Research Board of Canada, Bulletin 184, Catalogue No. FS94-184, Page 158 – line drawing of Coho Salmon.

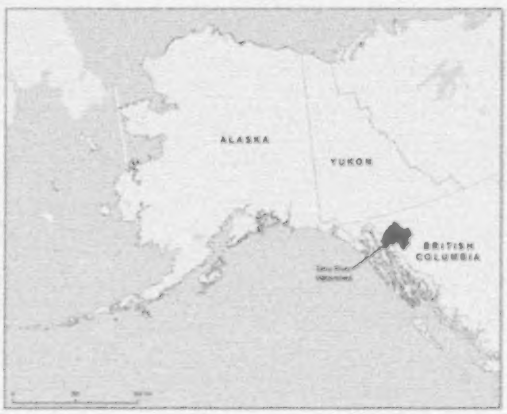


Figure 1. Map of the Taku River Watershed: a Transboundary river in NW British Columbia and SE Alaska (map provided by Alaska Department of Fish and Game).

Context:

Taku River Coho Salmon (Oncorhynchus kisutch) are a transboundary stock managed cooperatively by Canada and the United States under the Pacific Salmon Treaty (PST). The Transboundary Chapter of Annex IV of the treaty requires Parties to "develop a joint technical report and submit it through the various Parties' review mechanisms with the aim of identifying and establishing a bilaterally agreed to MSY goal for Taku coho". It was agreed by the Transboundary Panel of the PST that Canada would take the lead on addressing this obligation, and this assessment is the first milestone in this bilateral process. The purpose of this assessment is to estimate biological benchmarks, including the spawner abundance that maximizes sustainable yield over the long-term in average conditions (S_{MSY}) for Taku River Coho Salmon stock aggregate, which can then be used to evaluate status and set management goals.

This Science Advisory Report is from the November 3-4, 2014 Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for the Canadian-origin Taku River Coho Stock Aggregate. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

March 2015

Canada

SUMMARY

- Taku River Coho Salmon are a transboundary stock, managed cooperatively by Canada and the United States under provisions of Chapter 1, Annex IV of the Pacific Salmon Treaty (PST). The most recent provisions of the PST call for the development of a bilaterally-agreed spawning goal for Canadian-origin Taku River Coho Salmon set at the spawner level that maximizes sustainable yield (S_{MSY}).
- In addition to PST obligations, as part of implementing Strategy 1 of the Wild Salmon Policy (WSP), Fisheries and Oceans Canada (DFO) is required to identify biological benchmarks to assess the status of WSP Conservation Units (CUs) for Pacific salmon. Prior to this work, WSP benchmarks had not been estimated for Taku River Coho Salmon.
- To address PST commitments and support progress towards a WSP status assessment for Taku River Coho, an assessment to estimate biological benchmarks for spawner abundances of the Taku River Coho Salmon stock aggregate was undertaken.
- Data are available for Taku River Coho Salmon at the aggregate level, including spawner estimates based on a consistent mark-recapture survey covering the period 1987-2013, and recruitment estimates for the 1987 to 2009 brood years based on coded-wire tag recoveries in Alaskan and Canadian fisheries and surveys. Annual age and sex composition estimates are also available. These data are sufficient to estimate biological benchmarks based on spawner-recruit (SR) models.
- Eighteen model-data combinations were tested, covering six alternative data sets and three alternative SR model forms. Model fits and S_{MSY} estimates for Taku River Coho Salmon are remarkably consistent across all three alternative model forms and four variations of adult data, with medians ranging from 59,000 to 81,000 fish, so that the largest difference between any 2 of the 12 alternative S_{MSY} estimates is less than 40%. Model fits using juvenile data were much poorer than the adult fits, and produced S_{MSY} estimates that were much higher and much more uncertain (i.e. wider posterior distributions).
- Based on statistical and practical considerations, the DFO's regional peer review process chose one of the 18 model-data combinations as the most appropriate basis for advice regarding management goals for Taku River Coho Salmon: the Ricker AR1 model, which corrects for observed time-series patterns in residuals, fitted to estimates of total spawners and total adult recruits based on the age composition in the Canyon Island survey. For this model-data combination, biological benchmarks based on data for the 1987-2009 brood years are an estimated spawner level supporting maximum sustainable yield (S_{MSY}) of 69,000 fish [59,000-89,000 fish]; a spawner level that maximizes adult recruits (S_{MAX}) of 107,000 fish [82,000-154,000 fish]; and an equilibrium spawner level in the absence of fishing (S_{EQ}) of 183,000 fish [158,000-226,000 fish]. Values listed are the median and, in square brackets, the 10th percentile and 90th percentiles of the posterior distributions.
- Across all 18 model-data combinations, estimates of S_{MSY} are substantially higher than the spawning goal range of 27,500 to 35,000 fish used under the PST through 2012. However, the interim goal of 70,000 fish, adopted by the Transboundary Panel for 2014, falls in the middle of the range of S_{MSY} estimates across four adult data sets and three alternative models (59,000 to 81,000 spawners), and is essentially equal to the median S_{MSY} for the recommended model-data combination (69,000 spawners).

- Taku River Coho Salmon are currently delineated as a single CU under Canada's WSP (DFO 2005). Integrated WSP CU status assessments have used a suite of standardized metrics. For the recommended data-model combination, the Upper and Lower Benchmarks (BM) for the *Relative Abundance* metric are 71,000 spawners (90% probability of meeting or exceeding 80% of S_{MSY}) and 23,000 spawners (90% probability of rebuilding to S_{MSY} in one generation in the absence of fishing).
- Available data are sufficient to assess the other formal WSP metrics (i.e. extent of decline, short-term trend, probability of decline), but some of the supplementary information used in recent WSP status assessments is not available for Taku River Coho Salmon at this time (e.g. changing relative contribution of sub-populations). If future investigations indicate more than one CU exists for the Taku aggregate, SR-based assessment of WSP status may not be possible and other status assessment approaches would have to be explored.

BACKGROUND

The Taku River is a large transboundary river in northwestern British Columbia (B.C.). Approximately 90% of the 19,000 km^2 drainage area lies within B.C.; the remainder is located in Alaska, including the mouth of the river located roughly 45 km north-east of Juneau. The Taku River is the largest producer of Coho Salmon among the transboundary rivers, with a median aggregate total run size of 177,000 adults, ranging from 51,000 to 340,000 fish since 1990.

Three fisheries target salmon in the Canadian section of the Taku River: the Taku River Tlingit First Nation food, social and ceremonial (FSC) fishery, the recreational fishery and the commercial gillnet fishery. The commercial fishery and most of the FSC effort use gillnets set from outboard-driven riverboats in the lower river just upstream of the Canada-US border.

Fisheries in Alaska that also target Taku salmon stocks include the District 111 commercial drift gillnet fishery in Taku Inlet, the Juneau area sport fishery, and a limited personal use fishery in the lower Taku River in Alaska. S.E. Alaskan troll fishers also catch Taku salmon stocks in multi-stock fisheries which broadly target Chinook and Coho salmon. Seine fisheries conducted along the migration routes also may encounter Taku stocks, notably Sockeye and Pink Salmon.

Salmon stocks returning to the Taku River drainage are managed cooperatively by DFO and the Alaska Department of Fish and Game (ADFG) through the Canada/U.S. Transboundary Technical Committee of the Transboundary Rivers Panel established under the PST. Under provisions of the PST, Taku River Coho Salmon are managed as an aggregate. Specifically, the Transboundary Chapter of Annex IV of the PST requires Parties to "develop a joint technical report and submit it through the various Parties' review mechanisms with the aim of identifying and establishing a bilaterally agreed-to MSY goal for Taku River Coho". It was agreed by the Transboundary Panel that Canada would take the lead on addressing this obligation, and the Canadian Science Advisory Secretariat (CSAS) Research Document resulting from this regional peer review process is the first milestone in this bilateral process.

Median exploitation rate (ER) of Taku River Coho Salmon since 1990 is 49%, with most of the harvest (approximately 89%) taken by the US primarily in marine troll, gillnet and recreational fisheries; the remainder is harvested in small, in-river fisheries in Canada. The *Integrated Fisheries Management Plan* (DFO 2014) includes abundance-based trigger points for Canadian harvest measures, but no similar management reference points specific to Taku River Coho Salmon are in place for the Alaskan fisheries which harvest larger aggregates and account for the bulk of the total ER of Taku River Coho Salmon. As a result, total ER is driven by other factors, such as abundance of other species and stocks, weather, water levels, and price. ER

decreased substantially, from a peak of about 70% in the mid-1990s, to about 30% in the early 2000s, and since then increased gradually back to about 50%.

In addition to the above PST obligations, as part of implementing Strategy 1 of the WSP, DFO is required to identify biological benchmarks to assess the status of WSP CUs for Pacific salmon.

One Coho Salmon CU was initially identified for the Taku River based on ecotypic characteristics (Table 26 of Holtby and Ciruna 2007). However, subsequent unpublished work by Holtby and others has identified three potential CUs (TAKU-early timing, TAKU-mid-timing, and TAKU- late timing) based on run timing information and three main aquatic sub-ecotypes in the drainage. The current analyses reports information at the aggregate level, which could be used to assess WSP status of the single CU, if this delineation is confirmed.

To provide scientific advice to establish a biologically-based spawning goal for the transboundary Taku River Coho Salmon aggregate stock, the specific objectives for this assessment were to:

1. Review production, escapement and smolt abundance data for Coho Salmon originating in the Taku River upstream of the Canada-US border.
2. Develop biological benchmarks at the aggregate level, including the number of spawning adults that would produce a maximum sustainable yield of Coho Salmon using various models.
3. Examine and identify uncertainties in the data and methods.
4. Comment on future data needs and considerations which could allow development of biological benchmarks at the CU level.

DFO and ADFG, the two agencies responsible for salmon management, operate under similar policy frameworks and recent work related to biological benchmarks is conceptually consistent. However, there are important differences in both methodological details and subsequent use of the results, which affect how the results of biological analyses are presented. Therefore, the analysis covers the range of methods and definitions used in recent work published by DFO and ADFG. For example, recent assessments by ADFG have reported yield profiles (e.g. spawner range with 90% probability of at least 70% of maximum sustainable yield), whereas DFO assessments have focused on WSP status metrics and associated benchmarks (e.g. the relative abundance metric with an upper benchmark set at 80% of S_{MSY} and a lower benchmark set at S_{GEN}, which is the spawner abundance that allows rebuilding to S_{MSY} in one generation in the absence of fishing). Both types of reference ranges support the bilateral planning process. Note that the Research Document does not include a formal status assessment under either Alaska's Sustainable Salmon Policy (i.e. zones of yield concern, management concern, or conservation concern) or Canada's WSP (i.e. red, amber, or green integrated status), but the information in the Research Document sets the stage for both of these evaluations through domestic processes.

ANALYSIS

The analysis compared three alternative approaches for establishing a reference range for spawner abundance of the Taku River Coho Salmon aggregate. The work focused on fitting spawner-recruit (SR) models and estimating biological benchmarks for each model (e.g. spawner abundance that maximizes sustainable yield, S_{MSY}). However, some widely-used approximate methods for data-poor systems were also checked for consistency.

Compared to many other Coho Salmon populations, comprehensive spawner-recruit data are available for Taku River Coho Salmon at the aggregate level, including spawner estimates

based on a consistent mark-recapture survey covering the period 1987-2013, and recruitment estimates for the 1987 to 2009 brood years based on coded-wire tag recoveries in Alaskan and Canadian fisheries and surveys. These data are sufficient to estimate biological benchmarks based on spawner-recruit models, rather than falling back on some other approaches recently applied in data-poor systems (e.g. goals based on percentiles of observed spawner abundance).

Eighteen model-data combinations were tested, including six alternative data sets and three alternative spawner-recruit model forms. Data variations covered two alternative assumptions about age composition of adult recruits, using adult or smolt data, and using total spawners or female spawners expanded to adult equivalents. SR models covered the basic Ricker model, the Ricker model with autocorrelation correction (Ricker AR1), and the Kalman-filtered Ricker model with time-varying productivity.

Results

S_{MSY} estimates for Taku River Coho Salmon are remarkably consistent across alternative models for the base case data set (total spawners, adult recruits based on age composition estimated from Canyon Island survey data) and all available years of data (1987 -2009 brood years). Median estimates based on the three alternative SR models applied in these analyses range from 62,000 to 79,000 spawners, differing by less than 30% from each other.

S_{MSY} estimates for Taku River Coho Salmon are robust to variations in the spawner-to-adult data, but this observation is specific to the particular data set currently available. For example, the two alternative assumptions about age composition (based on Canyon Island vs. Canadian commercial and test fishery) have little effect on SR model fits and resulting benchmark estimates. This small difference between fits for adult data sets may not persist, and all the alternative data sets should be rechecked when the analysis is updated in a few years.

SR model fits based on smolt data are much poorer than the adult fits, but the effect on resulting benchmark estimates differs by model form. Several hypotheses could explain the observed discrepancies between juvenile and adult data.

S_{MSY} estimates for Taku River Coho Salmon based on adult data are highly stable across different estimation approaches, including different software packages and the application of a bias correction to the productivity parameter. Seven alternative Ricker fits produce median S_{MSY} estimates within 11% of each other.

The CSAS regional peer review process identified one of the of the 18 model-data combinations as the recommended basis for setting a spawning goal for this stock at this point in time (Ricker AR1 with Spn-Ad data, see corresponding benchmark estimates in Table 1 and Figure 2). However, the peer review process did not recommend a specific biological benchmark or reference range (i.e. whether to set the spawning goal based on median S_{MSY}, or relative to S_{GEN} and 80% S_{MSY}, or based on some yield-based range such as 90% probability of achieving 70% of MSY). Figure 2 shows the observed time series of total spawners relative to three biological benchmarks (S_{MSY}, S_{MAX}, S_{EQ}) for the recommended model-data combination.

Table 1. Biological Benchmarks for Taku River Coho Salmon. Estimates shown are for the Ricker model with lag-1 autocorrelation correction (Ricker AR1) fitted to observations of total spawners and total adult recruits based on Canyon Island survey data (Spn2Ad), which was chosen by the CSAS regional peer review process as the most appropriate among 18 alternative model-data combinations. All values were rounded to the nearest 1,000 spawners. Rows list the 10th, 25th, 50th, 75th, and 90th percentiles of the posterior distribution. Figure 2 below compares these estimates to observed spawner abundances since 1990.

	S_{MSY}	S_{MAX}	S_{EQ}
10p	59,000	82,000	158,000
25p	63,000	93,000	168,000
50p (Median)	**69,000**	**107,000**	**183,000**
85p	77,000	126,000	202,000
90p	89,000	154,000	226,000

This range covers 80% of the posterior probability distribution

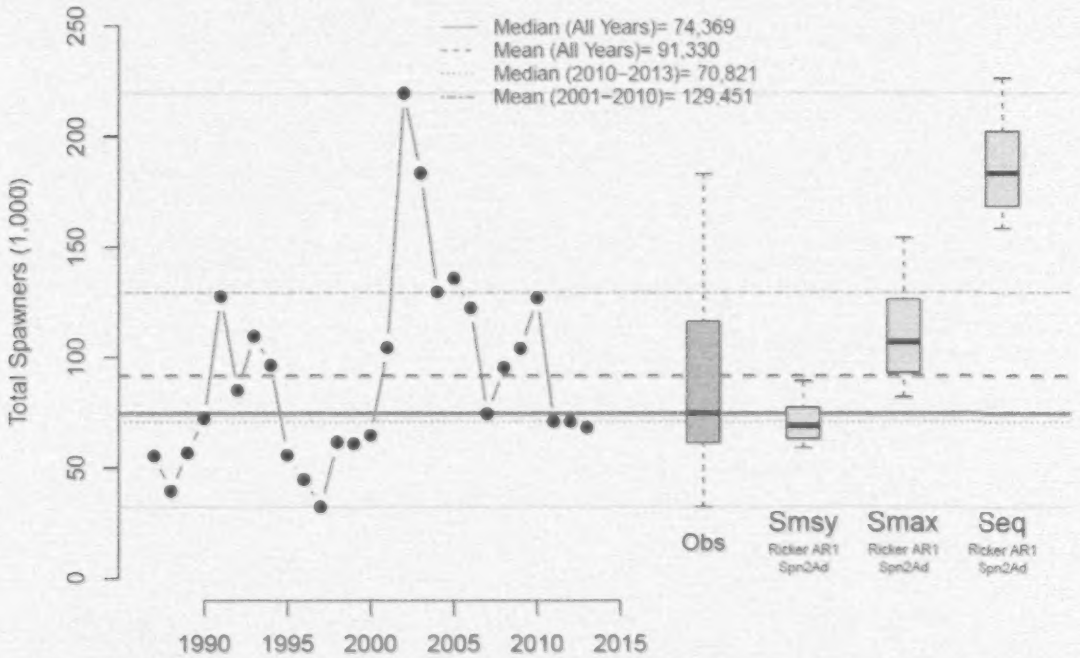


Figure 2. Observed pattern in spawner abundance of Taku River Coho Salmon compared to biological benchmarks for the recommended model-data combination. Benchmarks are for the Ricker model with lag-1 autocorrelation correction (Ricker AR1) fitted to observations of total spawners and total adult recruits based on Canyon Island survey data (Spn2Ad). Boxplots show 10th, 25th, 50th,75th, and 90th percentiles of the posterior distribution. Table 1 lists the benchmark values.

In addition to the biological benchmarks in Table 1, the analysis also presented a series of management reference points intended to capture relevant policy considerations applied by DFO and ADFG. Table 2 lists the definitions, and Table 3 summarizes the full suite of sensitivity analyses, with alternative reference point definitions across columns, and alternative biological assumptions (i.e. model-data combinations) down the rows.

Some biological benchmarks and reference ranges turned out to be much more sensitive to alternative model forms and data assumptions than others, and this observation affects the interpretation of results. Also note that the choice of method can have a very pronounced effect for some special cases. For example, S_{MSY} estimates based on juvenile data turned out to be highly sensitive to alternative estimation methods and choice of time period.

Recent implementations of similar analyses by DFO and ADFG differ in their use of bias corrections on the productivity parameter. Including the bias correction increases median S_{MSY} estimates and widens the posterior distribution, which in turn affects some of the summary reference points used to interpret the biological information. The question of when to apply this bias correction should be formally resolved. For Taku River Coho Salmon, this technical detail made little difference, but that observation may not hold for other systems or future updates of the Taku River Coho Salmon analyses (e.g. if estimates of the standard error were to increase).

SR model fits using simple linear regression and bootstrap intervals are a valuable cross-check for the more complex, and therefore more error-prone, Bayesian estimates. However, caution should be used when relying on the bootstrap-based benchmarks due to the potential for overly confident estimates.

Table 2. Definitions of Summary Reference Points (SRP) for Taku River Coho Salmon. Reference ranges are intended to capture considerations presented in recent US and Canadian analyses for other stocks.

Biological Benchmarks	Distribution Percentiles
SMSY50	Median of posterior distribution of S_{MSY}
LBM90	Spawner abundance with 90% probability of rebuilding to overall SMSY50 in 1 generation in the absence of fishing
UBM90	90^{th} percentile for the distribution of 80% of SMSY50
PGY90	Range of spawner abundances with 90% or more probability that the available yield meets or exceeds 70% of yield at SMSY50
X% Prob of Y% MSY	Range of spawner abundances with X% or more probability that the available yield meets or exceeds Y% of yield at SMSY50

Table 3. Summary Reference Points (SRP) for Taku River Coho Salmon – Alternative SR Models and Data Sets. Results are for six different data sets and three Ricker model variations (basic Ricker, Ricker AR1, Kalman-filtered Ricker) for a total of 18 sets of benchmark estimates based using Bayesian MCMC with BRugs and OpenBugs. All numbers are Spawners x 1,000. Data sets are labeled according to the following key: Spn for total spawners, FemSpn for female spawners expanded to total spawners based on long-term median sex ratio of 40%, Ad for total adult recruits using age composition from Canyon Island survey, AltAd for total adult recruits using age composition from Canadian commercial and test fishery, and Juv for total smolts. Empty cells in PGY90 indicate that yield profile never exceeds 90%. Empty cells for UBM90 are due to nonsensical values in the millions, because posteriors are very wide. 'Min' and 'max' for each column excludes the rows for Juvenile (Juv) data sets. The shaded row indicates the recommended peer-reviewed model-data combination from the possibilities explored in this analysis. The key points of this table are that the biological information captured in a spawner-recruit model can be summarized in different ways to inform a decision process (i.e. comparing across columns for a single row) and that these summaries can be sensitive to alternative biological assumptions (comparing across rows for a single column).

			WSP		PGY90		60% Prob of	
Data Set	**SR Model**	**S_{MSY}** (median)	**LBM90**	**UBM90**	**L**	**H**	**70% MSY**	**90% MSY**
Spn2Ad	Basic	79	32	98	55	98	35-123	57-98
-	**AR1**	69	**23**	**71**	**51**	**82**	**30-110**	**51-84**
-	Kalman*	62	34	72	--	--	30-101	53-72
Spn2AltAd	Basic	76	29	88	53	98	34-120	55-94
-	AR1	81	34	106	69	86	37-124	60-96
-	Kalman*	64	40	102	--	--	32-99	--
Spn2Juv	Basic	292	NA***	--	--	--	118-329	--
-	AR1	119	NA***	231	71	165	53-228	87-166
-	Kalman**	96	NA***	111	61	157	42-191	70-139
FemSpn2Ad	Basic	79	30	87	51	100	35-124	57-97
-	AR1	75	29	80	57	89	33-119	55-91
-	Kalman*	59	28	57	--	--	29-96	50-71
FemSpn2AltAd	Basic	79	30	86	54	101	34-124	57-96
-	AR1	81	33	93	64	87	36-124	59-96
-	Kalman*	64	38	72	--	--	31-98	58-70
FemSpn2Juv	Basic	237	NA***	--	124	185	99-349	175-242
-	AR1	124	NA***	199	72	178	55-242	91-178
-	Kalman**	100	NA***	114	68	156	44-193	74-139
Min (Adult)		59	23	57	51	82		
Max (Adult)		81	40	106	71	101		
%Diff (Adult)		37%	74%	100%	39%	23%		

* 2009 BY ** 2010 BY *** LBM90 not applicable to smolts (would require smolt to adult calculation)

Sources of Uncertainty

The following sources of uncertainty were identified in this assessment.

- *Observation error:* Available data for the Taku River Coho Salmon aggregate are of high quality relative to other Coho stocks or CUs (i.e. have more than 20 years of consistent mark-recapture and coded-wire tag data), but there may still be biases that affect the benchmark estimates. The Research Document supporting these analyses will include estimated standard errors for each observation along with a discussion of the implications of uncertainty in influential data points (e.g. 2002 and 2003 brood years). Future analyses could incorporate a more formal exploration of observation error by adding a Bayesian run reconstruction.
- *Alternative data assumptions:* The analysis included six data variations capturing alternative assumptions about adult age composition, different life-history stages (adult vs. smolt), and effective spawner levels (total spawners vs. female spawners). Results were robust across adult data variations.
- *Alternative model forms:* The analysis included three variations of the Ricker model. All three assume that productivity declines at large spawner levels, but they differ in how they interpret observed productivity patterns. Results were robust across these model variations. Future assessment could explore other model forms for completeness (e.g. Beverton-Holt model which has no density-dependent decline at larger spawner levels).
- *Alternative estimation approaches*: Benchmark estimates were confirmed using different estimation approaches and software tools (e.g. comparison with output from WSP software package by Holt and Ogden 2013).
- *Policy interpretation and variations in technical details:* For a given set of results (e.g. a single model-data combination and estimation approach), the numerical estimates were sensitive to the alternative policy interpretations and technical details of summary calculations (e.g. yield profiles, summary reference points). Future analyses could be streamlined with clear guidelines for methodological details.

CONCLUSIONS AND ADVICE

Data for Taku River Coho Salmon at the aggregate level are available and sufficient to estimate biological benchmarks based on spawner-recruit models. The 18 tested model-data combinations represent a comprehensive exploration of the sources of uncertainty, and are sufficient to conclude that estimates of biological benchmarks for Taku River Coho Salmon are highly robust, given currently available information. Other SR model forms, such as the Beverton-Holt or Logistic Hockey Stick that assume no density-dependent reduction in productivity at larger spawner abundances, could have been explored, but the three Ricker variations were considered sufficient. Ricker-based estimates tend to be more precautionary than Beverton-Holt-based estimates when fitted to data with observation error.

Model fits and S_{MSY} estimates for Taku River Coho salmon are remarkably consistent across all three alternative model forms and the four adult data sets, with medians ranging from 59,000 to 81,000 spawners, so that the largest difference between any two of the 12 alternative S_{MSY} estimates is less than 40%. Model fits using juvenile data were much poorer than the adult fits, and produced S_{MSY} estimates that were much higher and much more uncertain (i.e. wider posterior distributions).

Based on the following chain of considerations, a single set of results for subsequent planning processes is recommended for developing management goals for Taku River Coho Salmon:

1. Set aside the juvenile results (six of the 18 model-data combinations), because they had consistently worse fits based on a standard statistical criterion, and they also imply a different objective (i.e. maximizing smolt abundance is not the same as maximizing adult recruits).
2. Set aside the results for the Kalman-filtered Ricker model (four of remaining 12 model-data combinations), because they imply annual variation in S_{MSY} and their use would require a productivity forecast from the last available brood year. Kalman-filtered results may be useful for looking back in a status assessment, but it isn't practical for Taku River Coho Salmon to anchor management on a goal that changes annually.
3. Set aside results based on female spawners expanded to adult equivalents (4 of the remaining 8 model-data combinations). As with the Kalman-filter results, these may be informative for status assessment, but are not practical for management purposes.
4. Set aside results for the alternative recruit time series based on age composition in the Canadian commercial and test fisheries (two of remaining four), because the age composition data from the Canyon Island survey covers is considered more reliable (longer time window, mostly using fish wheel capture samples which has lower size-selectivity)
5. Set aside the basic Ricker results (one of remaining two), because the strong observed autocorrelation in residual plots and the formal Durbin-Watson test points to the Ricker AR1 model as more appropriate.

Therefore, the results for the Ricker AR1 model fitted to estimates of total spawners and adult recruits based on age composition from the Canyon Island survey is recommended to set management goals for Taku River Coho Salmon (Table 1, Table 3). For this model-data combination, biological benchmarks (10^{th} and 90^{th} percentiles of the posterior distribution, capturing 80% of the parameter samples), based on data for the 1987-2009 brood years are:

- Spawner level that maximizes sustainable yield (S_{MSY}) estimated at 69,000 fish (59,000 to 89,000 fish);
- Spawner level that maximizes adult recruits (S_{MAX}) estimated at 107,000 fish (82,000 to 154,000 fish);
- Equilibrium spawner level in the absence of fishing (S_{EQ}) estimated at 183,000 fish (158,000 to 226,000 fish).

It should be noted that the rationale for using these SR model results in a status assessment might differ (e.g. one might choose to consider the range of estimates across several alternative model forms).

Across all 18 model-data combinations, estimates of S_{MSY} are substantially higher than the spawning goal range of 27,500 to 35,000 spawning salmon used under the PST through 2012. However, the recently adopted interim goal of 70,000 spawning salmon established by the Transboundary Panel for 2014 falls in the middle of the range of S_{MSY} estimates across four adult data sets and three alternative models (59,000 to 81,000 spawning salmon) and is essentially equal to the median S_{MSY} for the recommended model-data combination (69,000 spawning salmon).

Lack of contrast in spawner abundance is a common challenge when fitting spawner-recruit models. In the case of Taku River Coho Salmon, the 2002 and 2003 brood years strongly

influence the spread of observations in the spawner-recruit scatterplots and resulting model fits. Additional spawner observations in the vicinity of 200,000 fish would greatly increase the information available for estimating the biological capacity of the Taku River Coho Salmon aggregate.

Taku River Coho Salmon are currently delineated as a single CU under Canada's WSP (DFO 2005). Integrated CU status assessments have used a suite of standardized metrics. For the recommended data-model combination, estimates of benchmarks (BM) for the *Relative Abundance* metric of the Taku River Coho Salmon aggregate are (numerical values refer to spawning salmon):

- Upper BM (UBM90): 71,000 spawners (90% probability of meeting or exceeding 80% of S_{MSY}); and
- Lower BM (LBM90): 23,000 spawners (90% probability of rebuilding to S_{MSY} in one generation in the absence of fishing).

Table 3 lists the corresponding estimates for the other model-data combinations.

Available data are sufficient to assess the other formal WSP metrics (i.e. extent of decline, short-term trend, probability of decline), but some of the supplementary information used in recent WSP status assessments is not available for Taku River Coho Salmon at this time (e.g. changing relative contribution of sub-populations). If future investigations indicate more than one CU exists for the Taku aggregate, SR-based assessment of WSP status may not be possible and other status assessment approaches would have to be explored.

SOURCES OF INFORMATION

This Science Advisory Report is from the November 3-4, 2014 Estimates of a Biologically-Based Spawning Goal and Biological Benchmarks for the Canadian-origin Taku River Coho Stock Aggregate. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Fisheries and Oceans Canada (DFO). 2014. Integrated Fisheries Management Plan for Transboundary Rivers Salmon 2014.

Fisheries and Oceans Canada (DFO). 2005. Canada's Policy for Conservation of Wild Pacific Salmon. Fisheries and Oceans Canada, Vancouver, BC. 34 p. (Accessed 9 January 2015)

Holt, C.A., and Ogden, A. 2013. Software for assessing status of Conservation Units under Canada's Wild Salmon Policy: Instructional manual. Can. Tech. Rep. Fish. Aquat. Sci. 3058: v + 43 p. (Accessed 9 January 2015)

Holtby LB and KA Ciruna. 2007. Conservation Units for Pacific Salmon under the Wild Salmon Policy. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/070. viii + 350. (Accessed 9 January 2015)

THIS REPORT IS AVAILABLE FROM THE:

Centre for Science Advice Pacific Region
Fisheries and Oceans Canada
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

Telephone: 250-756-7208
E-Mail: csap@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087
© Her Majesty the Queen in Right of Canada, 2015

Correct Citation for this Publication:

DFO. 2015. Estimates of a biologically-based spawning goal and biological benchmarks for the Canadian-origin Taku River Coho stock aggregate. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/008.

Aussi disponible en français :

MPO. 2015. Estimations d'un objectif de frai fondé sur des données biologiques et points de référence biologiques pour l'ensemble des stocks de saumon coho d'origine canadienne de la rivière Taku. Secr. can. de consult. sci. du MPO, Avis sci. 2015/008.